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List Recall in Children with Specific Language Impairment and Children who Stutter: A Preliminary Investigation

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List Recall in Children with Specific Language Impairment and Children who Stutter: A Preliminary Investigation

by

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Abstract

List Recall in Children with Specific Language Impairment and Children who Stutter: A Preliminary Investigation

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This thesis extends a previous pilot study with children who stutter (CWS) to include children with specific language impairment (CSLI). The current study examines lexical-semantic organization in these two clinical populations in hopes of comparing and contrasting behavioral profiles. The study employed a list-recall task to assess the lexical-semantic organization of 9 CWS, 5 CSLI, and 20 typically developing children matched for age and vocabulary. Similar to previous investigations, our child participants demonstrated the well-documented list position effects. With regard to recall accuracy, by-participant analyses revealed significant differences between CSLI and their age-matched peers; however, they did not reveal significant differences between the CWS and either of their control groups nor between the CSLI and CWS groups. Further, inspection of error distribution suggested significant differences in the number and types of errors the CSLI and control groups produced. The prevalence of unrelated and previous list errors in CSLI suggest that deficits in inhibitory processes as well as

perseveration may have affected their performance. Areas of overlap and divergence in the profiles of CWS and CSLI indicate continuity in the degree of lexical-semantic weakness as well as differences in lexical retrieval and executive functions among CSLI and CWS.

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INTRODUCTION

Recent investigations of language impairment have utilized a comparative approach to gain insights into the nature and areas of convergence and divergence between specific disorders and other language and/cognitive disorders. For example, researchers have compared and contrasted the behavioral profiles of children with specific language impairment (CSLI) on various linguistic and/or cognitive tasks to those of children with developmental dyslexia (Bishop & Snowling, 2004), attention deficit hyperactivity disorders (Oram Cardy, Tannock, Johnson, & Johnson, 2010), and high functioning autism (Bishop & Norbury, 2002; McGregor et al., 2011). This line of research has proven fruitful in identifying overlaps in the phenotypes of different disorders and in scrutinizing the validity of theoretical accounts of language and cognitive disorders. In the current study, we extend this approach to the study of two clinical groups that have not been directly compared, namely, CSLI and children who stutter (CWS).

Although specific language impairment (SLI) and stuttering are two distinct disorders, they do share certain common symptoms. For instance, both groups demonstrate significant deficits in the areas of expressive vocabulary and phonological development. The current study aims to examine the performance of CWS, CSLI, and typically developing (TD) peers matched for age (AM) and vocabulary (VM) on a list recall experiment. As part of a larger project, the goal of this research is to identify, compare, and contrast behavioral profiles in these two clinical populations and to understand how stuttering and/or SLI may (differentially) affect lexical-semantic organization.

Separate lines of research suggest that CWS and CSLI experience parallel difficulties with the semantic-phonological interface (i.e. the connections between semantic representations and the sound form of the word) and lexical storage and retrieval. In recent years, research has indicated that stuttering involves more than a motor disruption in the forward flow of speech. Using a variety of language measures, many studies suggest underlying linguistic processing differences in CWS as compared to children who do not stutter (CWNS) (Anderson, 2008; Anderson & Conture, 2000; Byrd, Conture, & Ohde, 2007; Hall, 2004; Wagovich & Bernstein Ratner, 2007). Based on their assessments of language and vocabulary, these studies provide evidence that differences may be lexical in nature, involving semantic-phonological connections and affecting both receptive and expressive vocabulary.

CSLI also experience difficulties with the semantic-phonological interface and lexical storage and retrieval. SLI manifests in multiple domains of language including phonological memory, syntax, and vocabulary. Just as with CWS, the expressive domain is typically the main locus of deficits. However, CSLI may present with expressive only or receptive/expressive impairment. The majority of research on SLI has concentrated on the expressive domain, and inquiries regarding lexical and semantic skills in CSLI have grown considerably in recent years. CSLI tend to demonstrate late onset of lexical acquisition, smaller vocabularies compared to TD peers, and word finding difficulties (Brackenbury & Pye, 2005; McGregor, 1997; Watkins, Kelly, Harbers, & Hollis, 1995), all suggesting some sort of lexical-semantic impairment. Further, other studies have shown problems with their phonological systems as well (Graf Estes, Evans, & Else-Quest, 2007; Zourou, Ecalle, Magnan, & Sanchez, 2010). Together, these deficits affect expressive vocabulary and word-learning in general profoundly.

Linguistic Processing in Children Who Stutter

Language

Numerous studies have cited dissociations (i.e., significant differences) between overall language skills and vocabulary as well as between receptive and expressive language in CWS. Findings repeatedly demonstrate lower vocabulary scores in comparison to overall language scores and lower expressive language scores in comparison to receptive language scores. In a review of lexical development and retrieval in CWS, Hall (2004) reported multiple studies that have demonstrated poorer vocabulary and increased dissociations between receptive and expressive language in CWS (Murray & Reed, 1977; Byrd & Cooper, 1989; Bernstein Ratner & Silverman, 2000; Miles & Bernstein Ratner, 2001; Silverman & Bernstein Ratner 2002). Results of additional studies provide more evidence for vocabulary deficits and receptive/expressive language dissociation in CWS (Anderson & Conture, 2000; Anderson, Pellowski, & Conture, 2005; Ryan, 1992; Wagovich & Bernstein Ratner, 2007). Despite these dissociations, however, most studies found that even though they scored lower than TD peers, CWS still scored within the normal range (Anderson, Pellowski, & Conture, 2005; Bernstein Ratner & Silverman, 2000; Murray & Reed, 1977; Ryan, 1992). While CWS may not fall outside of normal limits on these measures, the consistent finding of decreased performance calls attention to these dissociations as a unique difference and therefore clinical interest.

In the area of vocabulary, researchers have found several interesting differences in CWS. In keeping with findings in CWS based on traditional noun-based vocabulary assessments, Wagovich and Bernstein Ratner (2007) found that CWS had vocabulary gaps in verbs paralleling the noun vocabulary deficits in play-based conversation, indicating a general vocabulary deficit. Anderson and Conture (2000) hypothesized that semantic development lags behind syntactic development in CWS and as a result contributes to their disfluencies. The differences they saw based in naturalistic interactions as well as standardized testing, specifically between syntactic and semantic abilities, further illustrate the dissociation between language skills and vocabulary. It should be noted, however, that while the many studies have demonstrated the receptive vocabulary score difference using the *Peabody Picture Vocabulary Test* (*PPVT*; e.g. Murray & Reed, 1977; Anderson & Conture, 2000), Bernstein Ratner and Silverman (2000) did not find a significant difference between CWS and CWNS on this particular measure. Nevertheless, sufficient evidence exists to demonstrate at least some gap between vocabulary and language skills in CWS.

Beyond the dissociation between vocabulary and overall language skills, research has provided a robust base of evidence for dissociation between the receptive and expressive language domains of CWS. Results repeatedly indicate significantly lower expressive than receptive skills. Murray and Reed (1977) and Byrd and Cooper (1989) found that CWS had significantly lower expressive language skills in comparison with receptive language skills indicating dissociation between the expressive and receptive domains. Anderson, Pellowski, and Conture (2005) further illustrated dissociation, showing that the language skills of CWS were within normal limits, but significantly lower than TD peers. Their data showed that CWS exhibited three times as many instances of dissociation as their TD peers.

Phonology

Reports of the phonological skills and deficits in CWS are consistent with a dissociation hypothesis, suggesting dissociation between speech sounds and semantic representations (Anderson, et al., 2005; Byrd, et al., 2007; Hakim & Bernstein Ratner, 2004). Non-word repetition tasks allow researchers to assess phonology without concern for how semantics may be affecting the child's performance. Thus, these tasks are a good indicator of phonological memory. Hakim and Bernstein Ratner (2004) used such a task. They found that CWS scored lower on the non-word repetition tasks and made significantly more phoneme errors (specific types not specified) compared to CWNS. Extending this study, Anderson, Wagovich, and Hall (2006) demonstrated the same results in younger children. Further, in their study of dissociations across language domains in CWS, Anderson et al. (2005) also found the greatest dissociation of all between sound system development and overall language skills. These findings mark phonological development and skills as a significant area of deficit in CWS. Following this line of research, Byrd et al. (2007) suggest that CWS rely more on holistic than incremental processing. That is, they access words on a more global syllable shape level rather than relative to the individual sound segments at a later age than is developmentally expected. This evidence further suggests a lack of connection between speech sounds and associated semantic meanings.

Linguistic Processing in Children with Specific Language Impairment

Language

As a significant indicator of language impairment, word-finding deficits are an important avenue of research in SLI. Word finding difficulties are often identified through a discrepancy between receptive and expressive vocabulary measures (German, 1992). This sort of discrepancy harkens to the dissociation seen between receptive and expressive language domains in CWS. Studies have repeatedly cited word finding difficulties in CSLI, indicating the significance of this dissociation. Further, Watkins et al. (1995) documented lower type-token ratios in CSLI indicating smaller lexical diversity and expressive vocabularies.

Researchers have proposed several hypotheses in response to the language difficulties seen in CSLI. To account for the lexical-semantic difficulties seen in CSLI, Pizzioli and Schelstrate (2011) explored syntactic deficits. They proposed that CSLI depend heavily on the lexical semantic system as a compensatory mechanism for their weaker syntactic skills. In their hypothesis, the overactivation of the semantic system leads to its overuse resulting in underspecified semantic representations and decreased efficiency. They further cited Bragard and Schelstrate's (2007) proposal that the underspecificity may be related to word finding difficulties in addition to poor semantic representations as support for this hypothesis. Poor semantic representations presumably lack fully developed networks of characteristics and associates. McGregor, Friedman, Reilly, and Newman (2002) demonstrated CSLI's poor semantic representations with naming, defining, and drawing tasks. CSLI consistently performed poorly across these tasks, indicating incomplete semantic representations. Sheng and McGregor (2010) expanded the base of data for deficits in vocabulary size. They used a word association task to evaluate vocabulary size and lexical organization in CSLI. Their study revealed that relative to their age-matched peers, CSLI had fewer semantic responses, more phonological responses, and more errors overall. They attributed semantic deficits to overdependence on sound-based connections and dissociation between expressive and receptive vocabulary. Similar to Pizzioli and Schelstrate's (2011) and Bragard and Schelstrate's (2007) underspecificity hypotheses, Sheng and McGregor (2010) suggested that lexical items may not be missing, but rather weakly linked or entirely unlinked to others.

Phonology

Similar to their CWS counterparts, CSLI also demonstrate difficulties with phonology, particularly with short term phonological memory. Coady, Evans, and Kluender (2010) reported that CSLI performed worse on a non-word repetition task, especially with those words with lower frequency phonotactics (i.e. the frequency at which sounds occur adjacently or in combination within words). A meta-analysis of 23 studies revealed that CSLI performed at an average of 1.27 standard deviations below TD peers on a variety of nonword repetition tasks (Graf Estes, et al., 2007). Non-word repetition tasks require the subject to encode phonological information free from semantics and hence provide a measure of phonological memory and processing. These repeated results of non-word repetition deficits point to a problem with phonological memory in CSLI.

Evidence of poorer later literacy and academic performance also provides support for weakened phonology in CSLI. Parisse and Maillart (2007) found phonological deficits in French CSLI; their results indicated that the difference between CSLI and TD peers widens with age. Gray (2006) found that CSLI performed significantly more poorly on both phonological memory and vocabulary measures across development; moreover, the differences widened around age 6, once again suggesting that phonological skills develop at a slower rate in CSLI. Similarly, Aguilar-Mediavilla, Sanz-Torrent, and Serra-Raventos (2002) saw that CSLI appeared to plateau in phonological skills at younger developmental ages. Zourou, Ecalle, Magnan, and Sanchez's (2010) findings revealed that although after 2-3 years of schooling discrete phonological awareness skills were on par with peers, difficulty with literacy tasks suggested that these skills were fragile and not strong enough for more advanced phonological awareness tasks. Alt (2011) connected phonological deficits with the lexical learning issues seen in CSLI, asserting that the main problem lies in the initial encoding of a word. Together, these findings of poorer academic performance related to phonological skills indicate a significant area of concern for CSLI.

Both CWS and CSLI display marked deficits in vocabulary and phonological processing. Accordingly, both groups are hypothesized to have less specified semantic representations as well as weaker links between the semantic representation and phonological forms. Taken together, these factors indicate immaturity in their lexical-semantic systems. Comparison between a group with known linguistic processing deficits (CSLI) and a group with similar but perhaps less pronounced linguistic deficits (CWS) may reveal more specific evidence of their particular deficits.

List Recall Tasks and False Memory Paradigms

Multiple recent studies have used a particular version of the list recall task, namely, the false memory paradigm, to examine organization of the lexical-semantic system. This paradigm entails presenting lists of words that are semantically related to a non-presented thematic word or critical item (CI; see Table 2 for examples). The subjects are then asked to recall or recognize presented words depending on the design of that specific study. Roediger and McDermott (1995) found that adults often respond with the CI in addition to the presented words. They proposed that when adults encoded the presented words, whether consciously or subconsciously, they may have activated or connected the stimulus to a semantic associate. Evidence suggests that false memory effects (i.e., recall of the non-presented CI) change over development. Brainerd, Reyna, and Forrest (2002) found that false memories increased in children entering adolescence in comparison to 5 and 7 year-olds. Further, they saw similar effects as the subjects transitioned into young adulthood; i.e. young adults had more false memories than the adolescents. As children mature, vocabulary increases and more semantic associations are formed. With rapidly expanding vocabulary comes the need to organize the words efficiently. Thus, a more robust and specific web of semantic associations creates a greater likelihood of a connection to the CI.

Evidence also exists to support a role for phonological association in false memories. Using lists with phonological associates as opposed to the traditional lists of semantic associates, Sommers and Lewis (1999) demonstrated similar effects on the rate of false recalls. Westbury, Buchannan, and Brown's (2002) results revealed further support for phonological activation in a false memory list recall task. Seemingly, both phonological and semantic aspects of words are at play in lexical-semantic organization.

Accordingly, the list recall task provides insight into the organization of the mental lexicon. Research to date using this paradigm suggests both semantic and phonological components. Results of this research further indicate that performance on the task reflects the differences seen across lexical-semantic development in children.

Additionally, throughout this line of research, studies have demonstrated effects based on the serial presentation of the words. Namely, words presented near the beginning and end of lists tend to have higher recall rates than those presented in the middle of lists. This distribution forms a U-shaped curve, typically with a higher peak for the end of the list (Glanzer & Cunitz, 1966). The tendency to recall list-final words is called the recency effect, while the tendency for higher recall of words presented early in the list is called the primacy effect. Increased mental rehearsal time may cause the higher recall of list-initial words because of possible transfer to long term memory. Conversely, list-final words may still be accessible in the working memory as the subject responds (Tan & Ward, 2000). Words in the middle of the list carry neither of these advantages, presumably making them more difficult to recall.

Present Study

Dearden's (2010) recent pilot study employed a list recall task to investigate lexical and semantic organization in CWS. Findings did reveal poorer performance in CWS compared to CWNS, but the small study size may have prevented these results from reaching statistical significance. Using the same list recall paradigm, the present study expands the study to include 1 additional CWS and 5 CSLI in order compare the differences seen between groups as well as between the groups and their age-matched and vocabulary-matched TD peers' performance.

In light of the evidence for smaller vocabularies and poorer phonological memories, both CWS and CSLI are predicted to recall fewer list items than age-matched TD peers. Because list recall is dependent on vocabulary knowledge and memory capacity, we also expect to see correlations between factors such as age, vocabulary level, and phonological memory capacity and recall performance. Further, we anticipate that children will show better recall of list-final words, followed by list-initial and list-middle words.

We are also interested in the recall errors made by the participants. Given previous studies of naming errors and word finding difficulties in CSLI (German, 1992; McGregor, 1997; Sheng & McGregor, 2010), we expect the CSLI to make a higher number of errors than their AM peers. With regard to error distribution, previous studies have shown that CSLI are more likely to make errors that do not bear clear relationships to the target (McGregor, 1997; Sheng & McGregor, 2010) and errors that suggest poorer executive functions (Gillam & Hoffman, 2004; Mainela-Arnold, Evans & Coady, 2008;

Tomblin, Mainela-Arnod, & Zhang, 2007); hence we predict that CSLI will make proportionally more unrelated errors and errors of perseveration on this list recall task and comparatively less semantically or phonologically based errors. Because error profiles have not been investigated in CWS, we will explore the errors made by these children without a priori predictions.

While we predict that the CWS and CSLI groups will both make errors consistent with younger children of the same vocabulary level, it is predicted that the CSLI will demonstrate greater deficit. In comparison with CWS, CSLI will likely produce more errors overall because of their greater degree of linguistic impairment.

METHODS

Participants

A total of 34 children aged 4;2-10;6 participated in the study. Participants were all monolingual English speakers and had no history of neurological, hearing, or autism spectrum disorders. Parents referred their children to the study after hearing about it through email, fliers distributed in the Austin area, advertisements in a parenting magazine, or by word of mouth.

Participants consisted of 9 CWS, 5 CSLI, and 20 typically developing children (TD) who served as age matches (AM) and vocabulary matches (VM) for the CWS and CSLI groups. Eight of the TD served as matches for both a CWS and a CSLI. Ages were matched within 3 months, and VM were determined through raw scores on the *Expressive Vocabulary Test, Second Edition* (*EVT-2*; Williams, 2007). We chose to match on expressive vocabulary because the experimental task (list recall) requires retrieval of word forms, an expressive task. VM matches were made within 6 correct items. The mean ages were 7;1 (range 59-126 months) for CWS and 7;0 (range 77-97 months) for CSLI. The VM for CWS had a mean age of 6;0 (range 53-111), and the VM for CSLI had a mean age of 4;11 (range 50-70 months).

Inclusion criteria for all participants included (a) Nonverbal IQ above 80 as measured by the Matrices subtest of the *Kaufman Brief Intelligence Test – Second Edition* (*K-BIT-2*; Kaufman & Kaufman, 2003) or the *Test of Nonverbal Intelligence,* (*TONI-3;* Brown, Sherbenou & Johnsen, 1997)[1]; (b) normal hearing based on the American Speech-Language and Hearing Association hearing screening guidelines; and (c) no reported history of social, emotional, or psychiatric disturbances.

To confirm typical development, the TD participants met the following criteria: (a) scored no lower than 1 standard deviation below the mean on the following standardized assessments: the Non-word Repetition subtest of the *Comprehensive Test of Phonological Processing* (*CTOPP*; Wagner, Torgesen & Rashotte, 1999), the *Structured Photographic Expressive Language Test – Third Edition* (*SPELT-3*; Dawson, Stout & Eyer, 2003), and the *Test of Narrative Language* (*TNL*; Gillam & Pearson, 2004); (b) had no current or previous report of speech and language development concerns; and (c) had speech and language within normal limits as perceived by graduate clinicians and licensed speech-language pathologists.

Participants were classified into disordered populations based on additional criteria. Participants were deemed CWS if they previously or currently received treatment or services for stuttering or if they had a diagnosis of stuttering based on observation and testing by a licensed speech-language pathologist. The participants in the CSLI group met the following criteria: (a) current enrollment in special service for treatment of oral language impairments; and (b) a score of 1 standard deviation below the mean or poorer on at least one of the following 3 diagnostic tests: the Non-word Repetition subtest of the *CTOPP*, the *SPELT-3*, or the *TNL*.

[1] Participants FMG002 and FMG043 performed below normal limits on the *KBIT-2*. However, alternative non-verbal IQ assessment (i.e., TONI-3) confirmed that both fell within normal limits.

Additionally, all participants completed the Memory for Digits subtest of the *CTOPP*, the *Peabody Picture Vocabulary Test* (*PPVT-4*; Dunn & Dunn, 2007) and the *EVT-2*. These tests provided additional measures of verbal memory and vocabulary level and allowed for correlational analysis of vocabulary and verbal memory levels and performance on the list recall task. The CSLI and TD participants also completed the *SPELT-3*; CWS did not because previous research has not indicated any morphosyntactic deficits in this population. Table 1 lists mean scores for standardized measures for each group.

Table 1: Standardized test mean scores

	Age (months)	NVIQ	*PPVT-4*	*EVT-2*	*CTOPP NWR*	*CTOPP MD*	*SPELT-3*	*TNL*
CWS	84.67	117.75	118.0	116.0	9.38	10.38	n/a	105.75
SD	25.01	7.29	5.22	8.69	1.77	2.83	n/a	9.82
CWS AM	85.0	107.11	124.0	123.89	12.56	11.89	112.0	117.14
SD	23.49	19.85	11.12	8.28	2.24	0.59	12.26	9.12
CWS VM	71.89	110.78	129.89	123.56	10.83	12.57	112.38	114.71
SD	18.64	11.83	14.81	11.50	3.19	2.07	7.11	18.99
CSLI	84.0	95.75	92.60	89.0	6.80	7.20	73.25	79.0
SD	9.03	10.97	14.74	10.30	1.30	2.28	10.75	13.08
CSLI AM	84.0	118.60	132.20	123.80	10.60	11.20	108.6	118.0
SD	9.27	11.06	16.01	13.77	2.97	1.30	13.32	11.49
CSLI VM	58.8	101.0	120.0	113.60	10.50	11.50	107.0	113.50
SD	7.85	19.08	8.60	7.89	3.54	0.71	13.34	6.36

Stimuli

The same twelve lists of eight words each used in Dearden's (2010) pilot study served as the stimuli for the current investigation. Each list included eight words semantically related to a non-presented thematic word, termed a critical item (CI). Roediger and McDermott's (1995) false memory study and Nelson, McEnvoy, and Schreiber's (1998) word association norms were used to construct the lists. An online corpus containing 4,832 words in kindergarten- and first grade-aged children's lexicons (with homophones collapsed to higher frequency form) provided frequency of occurrence for each word to ensure that stimuli words were conducive to use with child participants (Storkel, Hoover, & Kieweg, 2008). Stimuli included early-acquired nouns, verbs, and adjectives found within this corpus with the exception of one (i.e. "fur" found in the list with the CI "soft"). According to the corpus, the log word frequencies ranged from 1.00 to 4.79 (M= 3.02, SD=0.77). Each word list was constructed semantically, but all presented words had at least one rhyme outside the list in order to allow for phonological intrusions along with the semantic intrusions. The corpus also provided the number of neighbors for each word, which ranged from 1 to 27. Table 2 lists the stimuli.

Table 2: List recall items

Critical Items	Presented Words
Cold	hot, wet, ice, sick, warm, snow, freeze, weather
Sweet	sour, candy, sugar, tooth, good, taste, pie, cake
High	low, up, tall, sky, kite, over, jump, tower
Black	white, dark, color, sheep, coal, blue, cat, gray
River	lake, stream, flow, boat, fish, run, water, creek
Window	glass, door, shade, curtain, look, frame, house, ledge
Sleep	dream, bed, night, pillow, rest, wake, peace, nap
Soft	hard, feather, skin, light, touch, silk, fur, loud
Bread	dough, food, eat, slice, bake, wheat, milk, toast
Chair	table, sit, couch, stool, legs, seat, bench, wood
Foot	shoe, toe, sock, hand, ball, smell, kick, soccer
Mountain	hill, climb, top, valley, bike, ski, goat, steep

Procedures

A female native English speaker with a standard American accent recorded stimuli lists in a soundproof booth using a digital Zoom H4 recorder. Each sound file consisted of one list with 2-second pauses between words. Three research assistants blinded to the purpose of the study verified intelligibility of the recordings by listening to and recording each of the words from all lists. All three correctly provided all list words.

Children were asked to listen to each of the 12 stimuli lists one at a time and attempt to recall as many of the 8 presented words as they could. Children completed the 12 lists over two to three sessions completing 4 to 6 lists during each, and examiners presented the lists in a random sequence to control for order effects. Prior to beginning the task, examiners provided the following instructions: “Now you will be listening to groups of words. There are eight words in each group. I want you to listen carefully because you have to tell the words back to me. Try to remember as many words as you can. Are you ready? Let’s practice first.” Instructions for the task were repeated for each session. The children were given 1-2 practice lists so that the examiner could ascertain understanding of the task. Examiners recorded the order in which the children gave their responses, including responses in error. After the child paused, the examiner confirmed with the child that he or she was finished providing all of the words he or she remembered before moving on to the next list. Throughout the sessions, examiners provided non-contingent positive feedback to encourage continued effort and motivation for the task.

Coding

Each response was coded into one of the following categories: 1) correct; 2) false memory; 3) phonological intrusion; 4) semantic intrusion; 5) phonological/semantic intrusion; 6) inflection error; 7) previous list error; 8) previous list error/phonological intrusion; 9) previous list error/semantic intrusion; 10) repetition; 11) unrelated error.

Correct responses were words presented in the list. A response of the CI constituted a false memory. Phonological intrusions included responses with the same onset and same number of syllables as a presented word or a rhyme with the presented word (e.g. *gray-great*, *nap-rap*). Errors coded as semantic intrusions had a categorical (e.g. *up-down*), functional (e.g. *bike-ride*), descriptive (e.g. *night-dark, wood-stick*), thematic (e.g. *jump-run*, *lake-pond*), or causal (e.g. *sick-sneeze*) relationship to a presented word. The phonological/semantic intrusion category included words that had both a phonological and semantic relationship with one or more of the presented words (e.g. *bike, climb-hike*). Inflection errors were those responses that were a correct response with additional morphology (e.g. *color-colors*, *taste-tasting*). Previous list errors were recalls from a previously presented list. Similarly, recalls coded as previous list error/phonological intrusions and previous list error/semantic intrusions were those that came from previous lists but also fell under the definitions of phonological and semantic intrusions for the current list. When a child repeated a correct recall more than once it was coded as a repetition. Any error that did not fall into any of these categories was coded as unrelated. For analysis all types of phonological errors (phonological intrusion, and previous list error/phonological intrusion) were collapsed into a single category. The same was done to include all semantic errors in a single category (false memory, semantic intrusion, and previous list error/semantic intrusion). Table 3 lists, defines, and provides examples of errors.

Table 3: Error codes and examples

Error Type	Code	Example Responses
False Memory – Subject provided thematic unpresented word.	FM	COLD: weather, snow, freeze, **cold**, sick ('Cold' is the critical unpresented word.)
Phonological Intrusion - Response had same onset (vowel, consonant, or consonant cluster) and same number of syllables, or rhymed with a word from the presented list.	PH	MOUNTAIN: goat, steep, valley, **deep** ('Deep' rhymes with 'steep'.)
Semantic Intrusion - Response was semantically related to any word from list.	SE	HIGH: tower, jump, sky, up, **down** ('Down' is categorically related to 'up'.)
Phonological/Semantic Intrusion - Response fit criteria for phonological *and* semantic intrusion.	PH/SE	BREAD: toast, **meat**, bake, slice ('Meat' rhymes with 'eat' and is categorically related to 'food'.)
Inflection Error - Response was a different form of a presented word.	INF	COLD: weather, snow, freeze, hot, **froze**, ice ('Froze' is the past tense inflection of 'freeze'.)
Previous List Error - Response was a word from a list presented previously within the same session.	PL	SWEET: pie, cake, taste, tooth, **fast** ('Fast' was presented in a previous list during the session and is not phonologically or semantically related to any words in this list.)
Previous List Error/ Phonological Intrusion - Response was a word from a list presented previously within the same session *and* fit criteria for phonological intrusion.	PL/PE	HIGH: tower, **sour** ('Sour' rhymes with 'tower' and was presented in the 'SWEET' list prior to 'HIGH'.)
Previous List Error/ Semantic Intrusion - Response was a word from a list presented previously within same session *and* fit criteria for semantic intrusion.	PL/SE	CHAIR: wood, logs, sit, **bed** ('Bed' is semantically related to 'couch' and was presented in the 'SLEEP' list prior to 'CHAIR'.)
Repetition - A correct response was repeated within the recall period for a particular list.	REP	SLEEP: peace, nap, bed, dream, **bed** (Although the first response of 'bed' was coded as correct, the second response was coded as a repetition.)
Unrelated Error - Response did not fit any of the above criteria, as judged by researchers.	UR	SOFT: touch, sin, **'moke'**, loud ('Moke' cannot be related semantically because it is a nonword, and is also not phonologically related to any of the list words.)

RESULTS

By-Participant Analyses

Recall Accuracy and Errors

Prior to statistical analysis, sums of correctly recalled words, errors, and error types were calculated for each participant. In addition, mean percentages of correct recalls were calculated for each participant by dividing the number of correctly recalled words by the total of 96 presented words across the 12 lists. The means were compiled to obtain a mean percentage for each of the 6 groups.

Two one-way Analysis of Variance (ANOVA) tests were used to compare means of the various groups. For the comparison between the CSLI triad groups (CSLI, AM, and VM), the group effect was significant, F (2, 12)=5.45, p=.02, $\eta_p 2$=.48. Bonferroni post-hoc tests revealed a significant difference only between the CSLI (M=.32, SE=.046) and their AM (M=.52, SE=.046), p=.028, whereas the VM children (M=.35, SE=.046) did not differ from either CSLI or AM. The CWS triad did not display a significant group effect, F(2,24)=1.98, p=.16, with CWS (M=.45, SE=.051), AM (M=.55, SE=.051), and VM (M=.42, SE=.051) recalling comparable number of words. Additionally, a t-test revealed no significant difference between the CSLI (M=.31, SE=.03) and CWS (M=.45, SE=.05) groups in percent of accurate recalls, t=-1.79, df=12, p=.1.

Each error was coded according to the descriptions in Table 3. Raw numbers of errors are presented in Table 4 (see Appendix A for means by group). To obtain the total number of phonological and semantic intrusions, certain categories were collapsed for analysis. “All phonological errors” included phonological intrusion and previous list error/phonological intrusion, and “all semantic errors” included false memory, semantic intrusion, and previous list error/semantic intrusion. The 5 CSLI made a total of 75 intrusion errors and their AM and VM controls made 29 and 51 errors, respectively. The 9 CWS made a total of 52 intrusion errors and their AM and VM controls made 64 and 54 errors, respectively.

Table 4: Error summary by group – raw totals

	False Memory	Phonological Intrusion	Semantic Intrusion	Phonological/ Semantic Intrusion	Inflection	Previous List	Previous list/ Phonological	Previous list/ Semantic	Repetition	Unrelated	ALL Phonological (PH, PH/SE, PL/PH)	ALL Semantic (SE, PH/SE, PL/SE, FM)
SLI	6	11	6	1	4	15	2	1	9	20	13	13
TD - SLI AM	7	4	3	3	1	5	1	0	2	3	5	10
TD - SLI VM	7	4	7	1	1	6	0	0	8	17	4	14
CWS	12	13	8	2	1	1	2	0	8	5	15	20
TD - CWS AM	12	11	5	2	1	5	0	0	17	11	11	17
TD - CWS VM	9	7	6	2	1	8	2	0	8	11	9	15

Raw number of errors was unequal across groups, so comparing proportions of each error type controlled for those differences across groups for our analysis. As illustrated in Figure 1, relative to AM children, CSLI made proportionally more unrelated and repetition errors and proportionally less semantic (encompassing false memory, semantic and previous list/semantic categories), and semantic/phonological errors. The two groups made similar proportions of previous list, inflection, and phonological errors (encompassing phonological and previous list/phonological categories). Relative to VM children, CSLI had a lower proportion of overall semantic errors (combining semantic, previous list/semantic, and false memory) and a higher proportion of phonological errors, whereas distribution of the other error categories was more or less comparable. The CSLI and VM were similar in that unrelated, repetition, and previous list errors comprised a majority of their recall errors (nearly 70%); in contrast, a minority of the AM group's errors (about 30%) belonged to these categories.

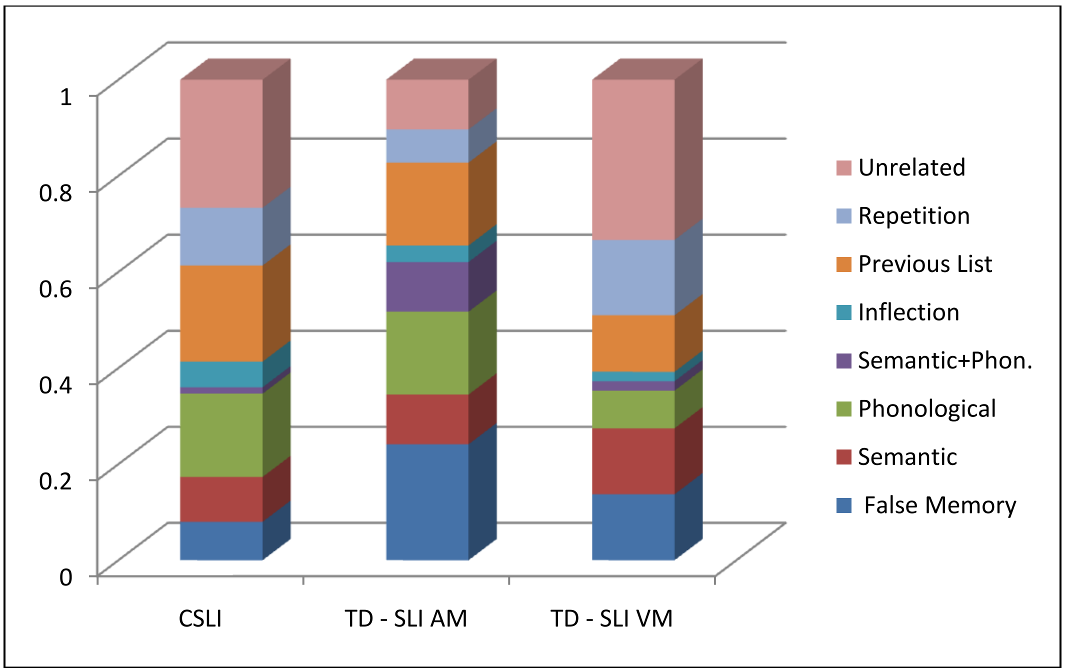

Figure 1. Distribution of recall errors in CSLI, AM, and VM groups. Phonological = phonological + previous list/phonological, Semantic = semantic + previous list/semantic.

Figure 2 shows the proportion of different errors among CWS and control groups. The AM and VM groups resembled each other more closely whereas the CWS showed a somewhat different profile. Specifically, the CWS made proportionally more phonological and semantic errors and relatively less unrelated and previous list errors.

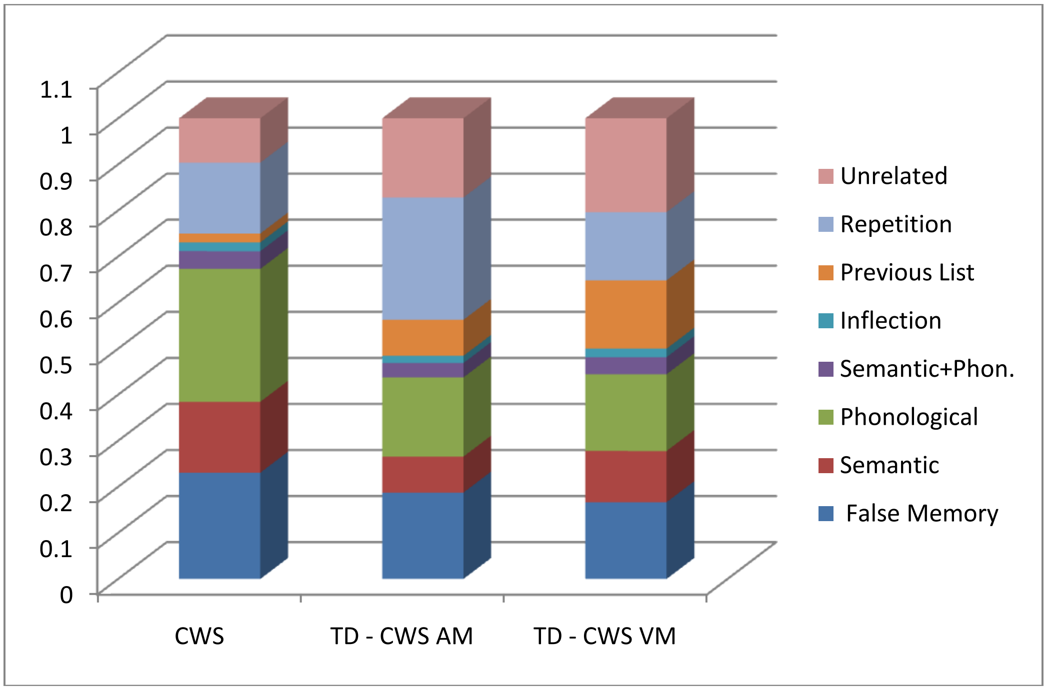

Figure 2. Distribution of recall errors in CWS, AM, and VM groups. Phonological = phonological + previous list/phonological, Semantic = semantic + previous list/semantic.

Figure 3 shows that when compared directly to CSLI, CWS were far more likely to recall words that were either phonologically or semantically related to presented words. Directly compared to CWS, CSLI were more likely to provide unrelated responses or perseverate on words from previous lists.

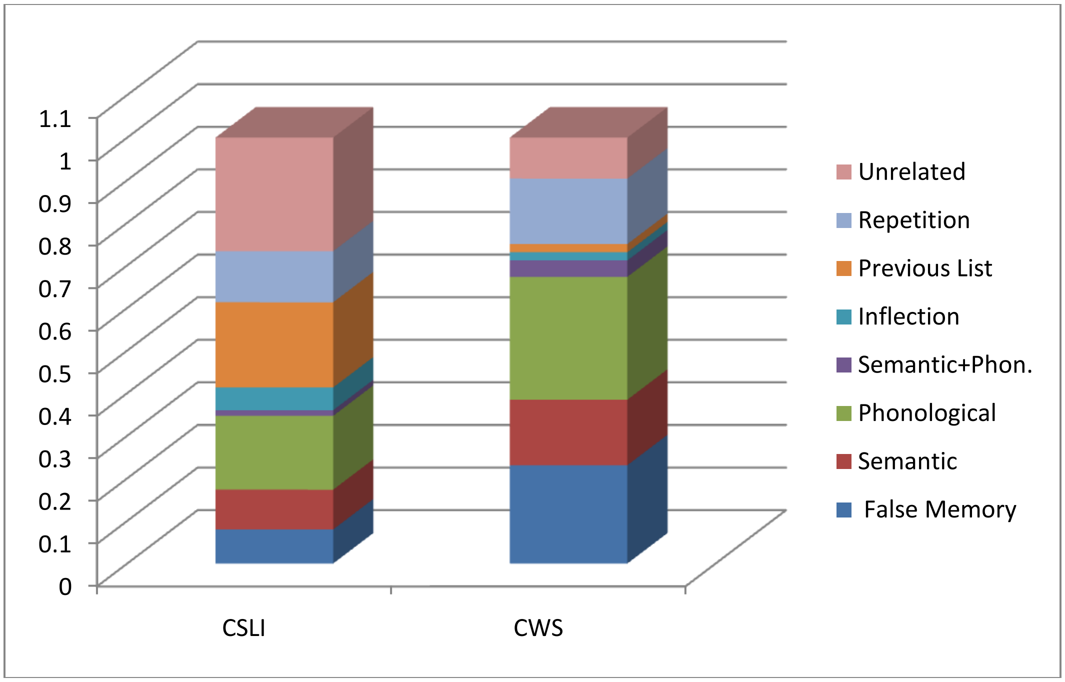

Figure 3. Distribution of recall errors in CSLI and CWS groups. Phonological = phonological + previous list/phonological, Semantic = semantic + previous list/semantic.

Correlations

Correlational analyses were conducted between participant age, standard scores on measures of vocabulary and verbal memory (i.e. *PPVT-4*, *EVT-2*, Memory for Digits and Non-word Repetition subtests of the *CTOPP*), and performance on the list recall task among the various talker groups. We selected percent accurate recall, overall semantic errors, overall phonological errors, previous list errors, repetition errors, and unrelated errors as the performance variables because these categories had relatively larger numbers. The correlations were conducted separately for the CSLI, the CWS, and the TD groups.

None of the correlations were significant for CSLI, but CWS displayed a correlation between age and percent of words recalled (r=.90, r^2=.80, p=.001, n=9,

t=5.36). As age increased, children recalled more of the presented words. The correlation between nonword repetition scores and number of unrelated errors approached significance, (r=.-68, r^2=.46, p=.06, n=8, t=-2.27). Children who had larger working memory capacities tended to make fewer unrelated errors.

Among the 20 TD matches, 4 significant correlations came to light. Percent of words recalled correlated positively with age (r=.95, r^2=.90, p<.001, n=20, t=12.56), and standard scores on the Memory for Digits subtest of the *CTOPP* (r=.53, r^2=.28, p=.034, n=20, t=2.35). Conversely, production of unrelated errors correlated negatively with both age (r=-.47, r^2=.22, p=.036, n=20, t=-2.26) and *PPVT-4* standard score (r=-.51, r^2=.26, p=.023, n=20, t=-2.48). Additionally, the correlation between standard scores on the Non-word Repetition subtest of the *CTOPP* and number of overall semantic errors approached significance (r=-.47, r^2=.22, p=.065, n=16, t=-2.01), meaning that children who scored better on the Non-Word repetition subtest of the *CTOPP* tended to make fewer overall semantic errors.

By-Item Analyses

To complement the by-participant analyses in previous sections, we conducted analyses by item. For each stimulus word, we tallied the number of children who produced a correct recall in each of the experimental groups (CSLI, CWS) and their respective control groups and derived a proportional value. For example, for the stimulus “wet” (CI “cold” list), we obtained proportional values of .2 for the CSLI group and .44 for the CWS group, meaning that 1 out of the 5 CSLI and 4 out of the 9 CWS correctly recalled this word. To account for primacy and recency effects, we divided the 8 list positions into 3 groups: first two words, middle four words, and last two words. Two repeated-measure ANOVAs were performed with list position (first, middle, last) as a between-item variable and group (experimental group, AM, VM) as a within-item variable, and proportion of children who correctly recalled an item as the dependent measure. Analysis by participant and by item enabled us to examine if the results were robust when averaged across words and/or when averaged across participants. The by-item analyses are likely to yield more significant findings because the number of items (n=96) exceeds the number of participants (n=15 for the CSLI comparison and n=27 for the CWS comparison).

For the ANOVA of the CSLI triad, as expected, there was a significant list position effect, $F(2, 93)=103.56$, $p<.001$, $\eta_p 2$ = .69. Across the CSLI triad, children recalled the final two words (M= .75, SE=.029) in the lists significantly more often than either the first two (M=.31, SE=.029) or middle four words (M=.25, SE=.021) of the list; recall of the latter two positions did not differ from each other. The ANOVA also revealed a significant group effect, $F(2,186)=27.15$, $p<.001$, $\eta_p^2=.23$, with more children in the AM group (M=.56, SE=.026) producing accurate recalls than either the CSLI (M=.36, SE=.021) or VM (M=.40, SE=.021) groups. The interaction between group and list position was also significant, $F(4,186)=3.69$, $p=.006$, $\eta_p^2=.07$. Specifically, the Bonferroni post-hoc tests revealed that a similarly low proportion of the CSLI and VM groups produced accurate recalls for words in the first and middle positions, but a significantly higher proportion of the AM recalled words in those positions. Further, for words in the list-final position, the proportion of children who generated correct recalls was comparable across all three groups. Figure 4 illustrates the interaction patterns.

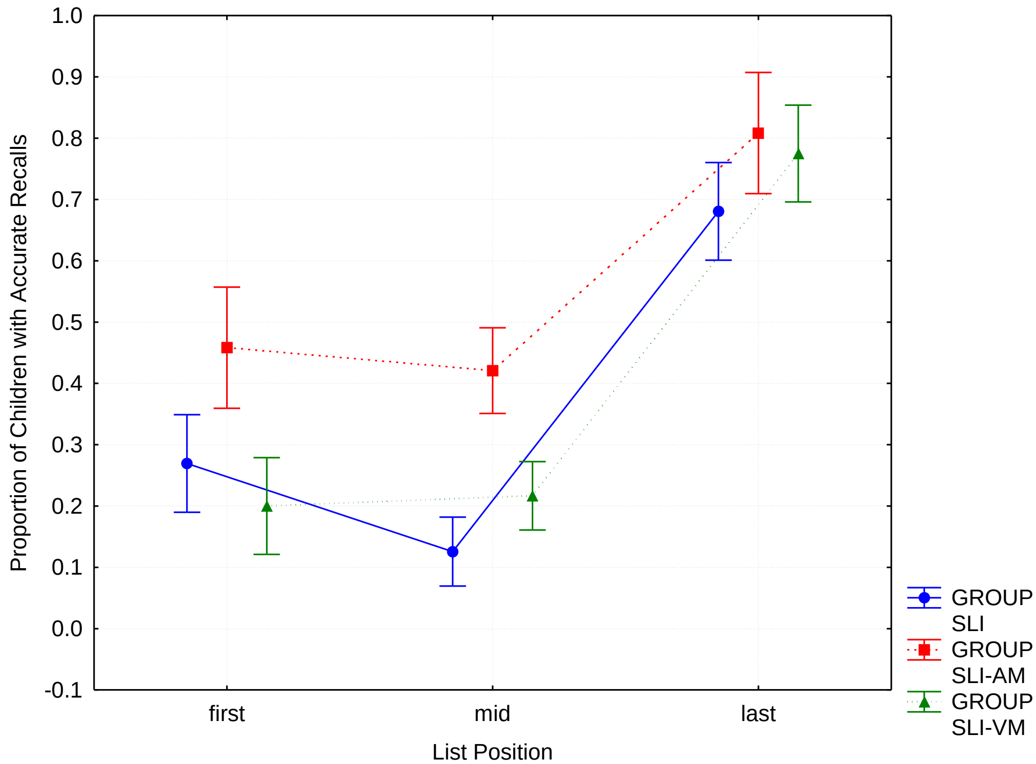

Figure 4: List position effect for CLSI, AM, and VM; bars indicate .95 confidence interval

The ANOVA for the CWS triad also yielded a list position effect, $F(1, 93) = 121.64$, $p < .001$, $\eta_p 2 = .72$, a group effect, $F(2, 186) = 26.34$, $p < .001$, $\eta_p 2 = .22$, and a group by list position interaction effect, $F(4, 186) = 6.21$, $p < .001$, $\eta_p 2 = .12$. Better recall of words in the list-final position (M=.79, SE=.024) than in list-initial (M=.34, SE=.017) and list-middle (M=.41, SE=.024) positions created this effect; recall of the latter two positions did not differ from each other. The group effect occurred as a result of the AM group's better performance (M= .59, SE=.017) than either the CWS (M=.51, SE=.017) or VM (M=.44, SE=.018) groups. Once again, the latter two groups were not different from each other. The interaction resulted from following patterns: in the list-initial position, CWS and AM performed similarly and better than the VM group; in the middle position, the AM performed better than the CWS and VM groups who performed similarly. Just as with the SLI triad, all groups in the CWS triad performed similarly in the final position. In addition, for CWS, performance in the three list positions differed significantly from each other (middle < first < final), for AM and VM groups, performance for the first and middle position was comparable, and both were poorer than the final position (first = middle < last). These patterns are presented in Figure 5.

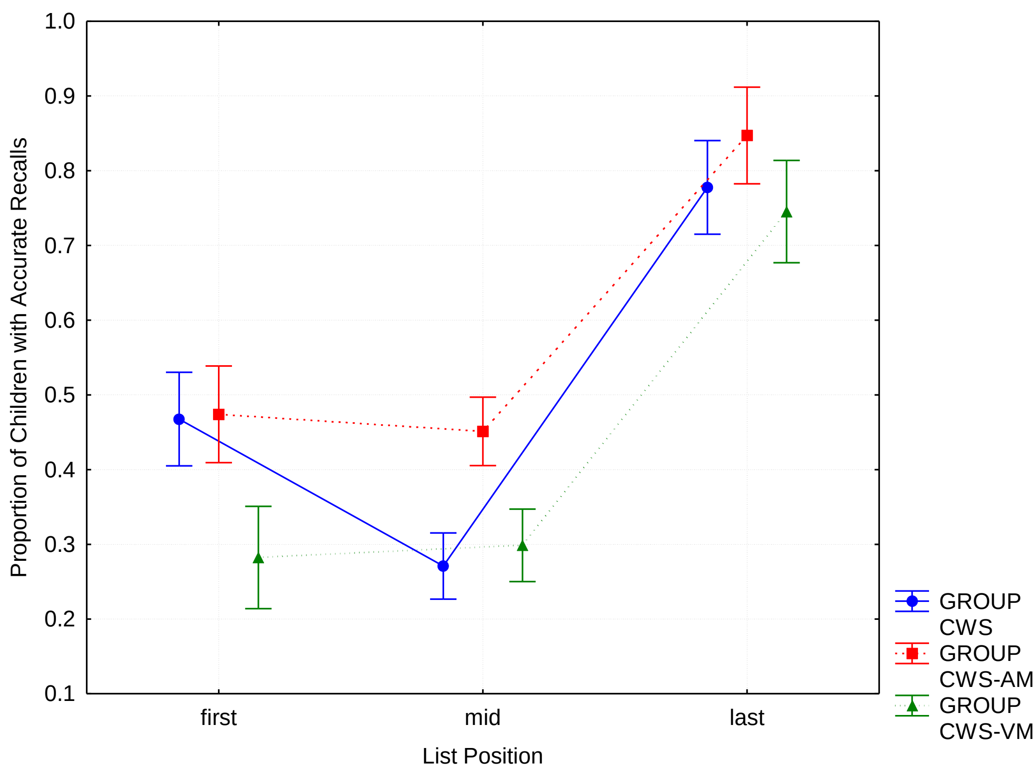

Figure 5: List position effect for CWS, CWS-AM, and CWS-VM; bars indicate .95 confidence interval

A third ANOVA was conducted with the experimental groups (CSLI, CWS) and list position (first, middle, final) as independent variables. As before, the list position effect was significant $F(2, 93)=111.59$, $p<.001$, $\eta_p2 = .71$, with list-final words ($M=.73$, $SE=.029$) showing better recall than list-initial words ($M=.37$, $SE=.029$) and both yielding better performance than list-middle words ($M=.20$, $SE=.021$). The group effect was also significant, $F(1, 93)=42.36$, $p<.001$, $\eta_p2 = .31$, with the CWS group ($M=.51$, $SE=.017$) performing significantly better than the CSLI group ($M=.36$, $SE=.021$). Although the position by group interaction was not statistically significant, $F(2, 93)=1.39$, $p=.254$, Bonferroni tests indicated that CSLI performed more poorly in the initial and middle list positions. But, in keeping with results seen among the triads, the groups performed similarly in the list-final position (Figure 6).

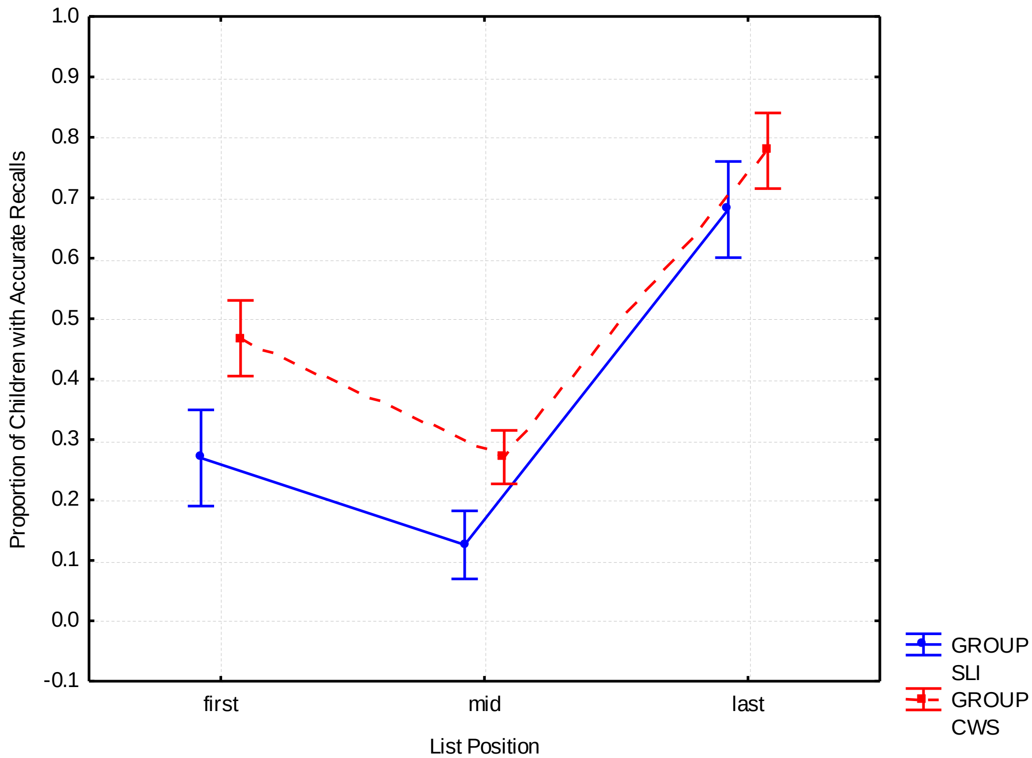

Figure 6: List position effects between CSLI and CWS; bars indicate .95 confidence interval

DISCUSSION

This study examined the list recall performance of 9 CWS, 5 CSLI and 20 TD children who served as AM and/or VM for the CWS and CSLI. We compared accuracy of recall as well as recall error types and proportions among CSLI and their controls, among CWS and their controls, and between CSLI and CWS. In addition, we examined the relationship of background variables such as age, vocabulary, and verbal memory with list recall performance. Finally, we investigated the effect of list position on recall accuracy. In the following sections, we summarize the main findings and discuss these results. Because of the limited sample size, our conclusions are preliminary in nature and must be treated with caution.

Recall Accuracy

With regard to recall accuracy, by-participant analyses revealed significant differences between CSLI and AM but not among the CWS triad or between the CSLI and CWS groups. On the other hand, by-item analyses indicated comparable performance between the clinical groups (both CSLI and CWS) and their VM controls and poorer performance in the clinical groups than their AM controls. Thus, the clinical populations performed at lower than age level. Of the two clinical groups, CSLI performed more poorly than CWS in by-item analyses. In general, the by-item analyses afforded more power for detection of subtle differences than the by-participant analyses as a result of more items than participants and more variability between the means across participants than between the means across items. More participants and equal numbers of participants across would further increase power for detection of these differences.

By-participant and by-item analyses converged on a finding of lower accuracy in list recall performance in CSLI than in AM controls. The CSLI recalled a similar number of items as their VM controls, who were on average 25 months younger. These patterns are consistent with previous reports documenting deficits in CSLI through various lexical-semantic tasks such as word learning (Gray, 2006), picture naming (McGregor, 1997), definition (McGregor et al., 2002), word association (Sheng & McGregor, 2010), and conversational discourse (Watkins et al., 1995). In addition, the deficits exhibited by CSLI appeared to be commensurate with their deficits in expressive vocabulary, suggesting that list recall is another task in which CSLI demonstrated a general delay rather than a delay within delay (Rice, 2003).

Relative to AM controls, the CWS's deficit in list recall was not significant in by-participant analyses but surfaced in the by-item analyses. The CWS recalled a similar number of items as their VM controls, who were on average 13 months younger. This profile coincides with previous studies showing subclinical differences in CWS's performance on tasks involving vocabulary and phonological memory (Anderson et al., 2005; Hall 2004; Hakim & Bernstein Ratner, 2004). This finding adds to an increasing body of research showing delayed development and/or decreased efficiency in the lexical-semantic systems of CWS.

Finally, CSLI and CWS did not perform significantly differently in by-participant analyses (p=.10); but this difference did reach statistical significance in the by-item analyses. Although both clinical groups appeared delayed, in terms of a continuum of lexical-semantic impairment, CSLI demonstrated more severe impairment compared with milder impairment in CWS.

Errors

Inspection of error distribution suggested significant differences in the number and types of errors the CSLI and control groups produced. CSLI made 2.6 times as many errors as their AM controls and 1.5 times as many errors as their VM controls. In comparison to their AM controls, CSLI demonstrated higher proportions of unrelated and repetition errors, lower proportions of semantically related errors (including false memory, semantic, and previous list/semantic), and comparable phonological errors. In comparison to younger VM controls, CSLI had less semantic errors but more phonological errors. These findings were reminiscent of Sheng and McGregor's (2010) study results wherein the CSLI also produced fewer semantic associations than both AM and VM controls, leading to a suggestion of difficulties activating the semantic networks associated with the presented lists. This under-activation may result from a smaller lexicon and/or a sparsely connected network (Sheng & McGregor, 2010). In addition, the excessive production of unrelated errors and repetitions in CSLI may be attributed to less specific semantic representations as well as poorer inhibitory control (Pizzioli & Schelstrate, 2011).

In contrast, CWS and their AM and VM controls made comparable numbers of errors on this list recall task. When error proportions were examined, CWS appeared to have made more phonological and semantic errors and less unrelated and previous list errors than the control groups. These patterns may indicate more strategic and careful consideration in completion of the task or greater inhibition of obviously incorrect responses. Underlying lexical-semantic inefficiency may result in the need for increased concentration to perform accurately and thus increased diligence in completion of the task.

CSLI produced a much greater number of errors in comparison to the CWS. In terms of error proportions, the greatest difference lay in the over-production of unrelated and previous list errors and under-production of phonological and semantic intrusions in the CSLI relative to CWS. These patterns pointed to less developed lexical-semantic networks as well as poorer ability to inhibit irrelevant responses or resist the tendency to perseverate on previously recalled words on the part of the CSLI. It is still unclear whether the CSLI's difficulties with inhibitory control are specific to underdeveloped lexical-semantic representations or a result of a delay in general attentional control. However, increased vulnerability to competition or poorer suppression of unrelated meanings have been documented in previous investigations of lexical representation, sentence processing, or even nonverbal procedural learning in CSLI (Mainela-Arnold et al., 2008, Norbury, 2005; Tomblin et al., 2007). These patterns suggest that the deficits may lie in the domain-general executive function component of the working memory system that spans multiple cognitive tasks (Gillam & Hoffman, 2004).By contrast, the profiles of the CWS are suggestive of intact and isolated and subtle difficulties with lexical-semantic representation.

Correlations

Several correlations came to light between participant background variables (e.g., age and standard scores) and list recall performance. In both CWS and the TD children, increased age was associated with increased accuracy of recall. Along with age, scores on the Memory for Digits subtest of the *CTOPP* correlated positively with percent of list items recalled among the TD children and negatively with number of unrelated errors among the CWS (p=.06). As a measure of working memory, it makes sense that increased performance on this task would predict performance on list recall, another memory-based task. Apart from recall accuracy, TD children presented with correlations to specific error types as well. Age and *PPVT-4* scores correlated negatively with unrelated errors. As children mature, cognitive skills such as inhibitory control increase, which would explain why unrelated errors might decrease with age. Increased *PPVT-4* scores indicate a more developed vocabulary and possibly stronger and more specified semantic representations. As vocabulary became more developed and presumably more specified in TD children, they were able to eliminate the incorrect responses. Finally, scores on the Non-word Repetition subtest of the *CTOPP* correlated negatively (p=.07) with overall semantic errors. In other words, children with better phonological memories made fewer semantic errors. A better phonological memory would enable children to form more detailed phonological representations of presented words. More precise memory of the phonological forms of the presented words may allow children to reject semantically related errors at the point of recall. A correlation connecting improved phonological skills with a reduction of semantic errors supports a connection between these two domains of word knowledge. This cross-domain relationship reiterates previous findings. For example, in a novel word learning task, Storkel (2001) found that phonotactic probability of the novel words influenced the formation of semantic representations and the association between semantic and lexical representations of the newly-learned words.

List Position Effects

Similar to previous investigations, our child participants demonstrated the well-documented list position effects. In particular, words in the list-final position exhibited a special advantage in recall over words in either initial or middle positions because list-final words are still retained in working memory at the time of recall. In contrast, words in either list-initial or list-middle positions have suffered some degree of decay in the working memory (Glanzer & Cunitz, 1966; Tan & Ward, 2000). The fact that all children, regardless of diagnosis, were able to recall the last two words in the list with comparably high accuracy (ranging from 68% to 85% depending on group) speaks to the robustness of this effect. Even children who have presumably less mature lexical-semantic systems were able to compensate for their deficits and achieve age-appropriate accuracy for list-final words.

On the other hand, the primacy effect, or better recall of list-initial than list-middle words, manifested only in the two clinical groups and not in the TD children. As seen in Figures 4 to 6, the AM children recalled these two types of words with equally high accuracy, the VM children recalled these words with equally low accuracy, and the two clinical groups (CSLI and CWS) recalled words at the beginning of the list better than those in the middle. The list-initial recall advantage is typically attributed to the increased opportunities for rehearsal of these items, which may result in these words' transfer to long-term memory. In the meantime, words in the middle of the lists are particularly difficult because they are conducive to neither rehearsal nor temporary storage in working memory. It is possible that the VM children were too young to make use of the rehearsal strategy, leading to depressed recall of list-initial words. The AM children, on the other hand, may have large enough memory capacity and/or proficient rehearsal mechanisms to accommodate both list-initial and list-middle words. The CSLI and CWS may have the cognitive maturity to employ rehearsal strategies, which enhanced recall of list-initial words but still lacked the memory capacity to boost recall of list-middle words. However, a few TD children served as AM for one group and VM or the other group. Neither AM group demonstrated a significant difference, so this hypothesis needs to be taken with caution. Additional participants may help verify this claim.

Finally, direct comparisons between the CSLI and CWS revealed that CSLI performed more poorly in the first and middle positions. In addition, Figures 4 and 5 illustrate that while both CSLI and CWS demonstrated a primacy effect, only the CWS were able to elevate their accuracy to the level of the AM peers for these words. These findings suggest that CWS may be more proficient at deploying cognitive strategies such as rehearsal than CSLI.

Conclusion

In this preliminary investigation of list recall performance, we found areas of overlaps as well as lines of separation in the performance profiles of CWS and CSLI. Both groups lagged behind their AM peers and paired closely with their VM peers in recall accuracy. The two clinical groups' recall performance mapped onto a continuum with CWS showing mild impairment and CSLI showing more severe impairment. Both groups had particular difficulty recalling words in the most demanding list position, i.e. the list-middle words. Accordingly, both groups demonstrated primacy and recency effects, suggesting that basic cognitive processes such as rehearsal and short-term memory storage are intact and might be at play. Analyses of recall errors indicated that CSLI had difficulties accessing semantic information, problems with inhibiting irrelevant information, and tendency to perseverate on previously presented words. In contrast, CWS showed a distinct error profile marked by a predominance of semantic and phonological errors and rare occurrence of unrelated and perseveration errors. These findings are indicative of continuity in the degree of lexical-semantic weakness as well as differences in lexical retrieval and executive functions among CSLI and CWS.

RECOMMENDATIONS

The purpose of this study was to extend Dearden's (2010) pilot study to include CSLI for further comparison with CWS and TD AM and VM. These procedures may prove useful for further extension of the study. In the future, recalls of stimuli items could be analyzed by neighborhood density and word frequency in order to see if these factors affect the rate of recall. Byrd et al. (2007) showed that CWS struggle more to recall words with higher density phonological neighborhoods. Bearing in mind that CSLI also demonstrate phonological deficits, both groups may show poorer recall on such items. Given evidence of poorer vocabularies and immature lexical-semantic systems in CWS and CSLI, the effects of semantic density and word frequency of the stimuli could yield valuable results. Effects of neighborhood density and word frequency on the type of errors would reveal more insight into the specific areas of phonological and/or semantic deficit in these populations.

The small number of participants (9 CWS and 5 CSLI) in this study limits the effects seen in analysis and prevents acceptable generalization. Inclusion of more participants and equal numbers of participants across groups would hopefully bring out the meaningful differences among the groups more definitively. Because CSLI and CWS are rather heterogeneous in their impairment and behavioral profile, analyses to more closely examine individual performance would likely prove helpful for future research. For example, FMG001 (a CSLI) provided 4 consecutive rhymes with a recall on his second list. However, the first was a previously presented word that rhymed with a word from the current list that he recalled. Similarly, FMG003 (also a CSLI) repeatedly provided previously presented words independent of any connection to the current list (see Appendix B for individual performance data). These sorts of idiosyncratic tendencies may have a significant effect on such a small sample size, which is why more participants are needed to develop more solid conclusions.

Appendix A

Mean error types by group

	False Memory	Phonological Intrusion	Semantic Intrusion	Phonological/ Semantic Intrusion	Inflection	Previous List	Previous list/ Phonological	Previous list/ Semantic	Repetition	Unrelated	ALL Phonological (PH, PH/SE, PL/PH)	ALL Semantic (SE, PH/SE, PL/SE, FM)
SLI	1.20	2.20	1.20	0.20	0.80	3.00	0.40	0.20	1.80	4.00	2.80	2.80
SD	0.45	2.28	0.84	0.45	0.84	4.06	0.55	0.45	1.64	2.35	2.05	0.84
TD - SLI AM	1.40	0.80	0.60	0.60	0.20	1.00	0.20	0.00	0.40	0.60	1.60	2.60
SD	0.89	0.84	0.89	0.89	0.45	1.73	0.45	0.00	0.89	0.89	1.14	1.52
TD - SLI VM	1.40	0.80	1.40	0.20	0.20	1.20	0.00	0.00	1.60	3.40	1.00	3.00
SD	1.52	0.84	0.55	0.45	0.45	1.64	0.00	0.00	1.82	2.61	0.71	1.22
CWS	1.33	1.44	0.89	0.22	0.11	0.11	0.22	0.00	0.89	0.56	1.89	2.44
SD	1.12	1.51	1.05	0.44	0.33	0.33	0.44	0.00	1.05	0.53	1.69	1.94
TD - CWS AM	1.33	1.22	0.56	0.22	0.11	0.56	0.00	0.00	1.89	1.22	1.44	2.11
SD	1.12	1.48	0.73	0.44	0.33	1.33	0.00	0.00	1.96	2.22	1.67	1.54
TD - CWS VM	1.00	0.78	0.67	0.22	0.11	0.89	0.22	0.00	0.89	1.22	1.22	1.89
SD	1.00	0.83	1.00	0.67	0.33	1.36	0.67	0.00	1.17	1.56	1.30	1.45

Appendix B

Subject	Group	Sex	Age (mo.)	Recalls	% Recalled	FM	PH	SE	PH/SE	INF	PL	PL/PH	PL/SE	REP	UR	ALL PH	ALL SE
FMG001	SLI	M	78	68	70.8%	0	0	0	0	0	0	0	0	0	0	0	0
FMG002	SLI	M	97	12	12.5%	0	0	1	0	0	0	0	0	0	0	0	1
FMG003	SLI	M	77	10	10.4%	3	0	0	0	0	0	1	0	0	1	1	3
FMG005	TD	M	90	0	0.0%	0	0	0	0	0	0	0	0	0	0	0	0
FMG006	CWS	M	75	46	47.9%	0	0	0	0	0	0	0	0	0	0	0	0
FMG007	CWS	F	69	21	21.9%	0	0	0	0	0	0	0	0	0	0	0	0
FMG009	TD	M	97	19	19.8%	1	0	0	0	0	0	0	0	3	1	0	1
FMG010	TD	M	67	27	28.1%	0	0	0	0	0	0	0	0	0	0	0	0
FMG013	CWS	M	121	14	14.6%	2	2	2	0	0	1	0	0	0	0	2	4
FMG014	CWS	F	66	14	14.6%	1	1	1	0	0	0	0	0	0	1	1	2
FMG015	TD	F	72	32	33.3%	0	0	0	0	0	0	0	0	0	0	0	0
FMG016	CWS	M	70	45	46.9%	0	0	0	0	0	0	0	0	0	0	0	0
FMG017	TD	M	70	18	18.8%	2	3	0	0	0	0	0	0	0	0	3	2
FMG018	CWS	F	59	9	9.4%	0	0	0	0	0	1	0	0	0	1	0	0
FMG019	CWS	M	102	22	22.9%	1	0	0	0	1	0	0	0	1	0	0	1
FMG020	CWS	M	74	29	30.2%	0	0	0	0	0	0	0	0	0	0	0	0
FMG021	TD	M	75	42	43.8%	0	0	0	0	0	0	0	0	0	0	0	0
FMG022	TD	M	77	16	16.7%	1	0	0	0	0	0	0	0	0	1	0	1
FMG026	TD	F	62	31	32.3%	0	0	0	0	0	0	0	0	0	0	0	0
FMG027	SLI	M	90	15	15.6%	0	1	0	0	1	1	0	0	0	3	1	0
FMG028	SLI	F	78	7	7.3%	0	1	0	0	0	2	0	0	0	4	1	0
FMG031	TD	M	50	49	51.0%	0	0	0	0	0	0	0	0	0	0	0	0
FMG032	TD	M	81	14	14.6%	0	2	0	0	0	0	0	0	0	1	2	0
FMG033	CWS	F	126	14	14.6%	0	0	0	0	0	1	0	0	1	0	0	0
FMG034	TD	F	53	11	11.5%	2	0	0	0	0	0	0	0	5	0	0	2
FMG035	TD	M	99	34	35.4%	0	0	0	0	0	0	0	0	2	0	0	0
FMG036	TD	M	118	44	45.8%	0	0	0	0	0	0	0	0	0	0	0	0
FMG037	TD	M	62	15	15.6%	1	2	0	0	0	0	0	0	0	2	2	1
FMG038	TD	M	66	7	7.3%	0	0	0	0	0	0	0	0	0	3	0	0
FMG039	TD	F	62	13	13.5%	0	0	1	0	0	0	0	0	1	0	0	1
FMG040	TD	M	59	32	33.3%	0	0	0	0	0	0	0	0	0	0	0	0
FMG041	TD	M	126	58	60.4%	0	0	0	0	0	0	0	0	0	0	0	0
FMG042	TD	F	111	9	9.4%	0	0	1	0	0	0	0	0	1	1	0	1
FMG043	TD	M	62	7	7.3%	0	1	2	0	0	0	0	0	0	2	1	2

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